

WHAT IS CLAIMED IS:

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1. A method for embedding digital watermark data in digital data contents, said method comprising the steps of:

10 receiving said digital data contents and said digital watermark data;

dividing said digital data contents into block data;

obtaining a frequency coefficient of said block data;

15 obtaining a complexity of said block data; obtaining an amount of transformation of said frequency coefficient from said complexity and said digital watermark data by using a quantization width;

20 embedding said digital watermark data in said digital data contents by transforming said frequency coefficient by said amount; and

generating watermarked digital data contents.

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30 2. The method as claimed in claim 1, said step of obtaining said complexity of said block data comprising the steps of:

transforming said block data, by applying a wavelet transform, into coefficients of said wavelet transform, and

35 obtaining said complexity on the basis of the number of high frequency coefficients in said coefficients of said wavelet transform, each of said

high frequency coefficients exceeding a threshold.

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3. A method for embedding digital watermark data in digital data contents, said method comprising the steps of:

receiving said digital data contents and  
10 said digital watermark data;

dividing said digital data contents into  
block data;

obtaining a frequency coefficient of said  
block data;

15 obtaining an amount of transformation of  
said frequency coefficient from said digital  
watermark data by using a quantization width  
corresponding to said frequency coefficient, said  
quantization width being obtained beforehand  
20 according to a manipulation method of said digital  
data contents;

embedding said digital watermark data in  
said digital data contents by transforming said  
frequency coefficient by said amount; and

25 generating watermarked digital data  
contents.

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4. The method as claimed in claim 3,  
wherein said quantization width is obtained by a  
method comprising the steps of:

35 dividing first digital data contents into  
one or a plurality of first block data;

dividing second digital data contents into  
one or a plurality of second block data, said second

digital data contents being obtained by manipulating said first digital data contents with a predetermined manipulation method;

5 transforming said first block data and said second block data into first frequency coefficients and second frequency coefficients respectively by applying an orthogonal transform;

10 obtaining difference values between said first frequency coefficients and said second frequency coefficients for each frequency coefficient;

calculating a standard deviation of distribution of said difference values; and

15 obtaining said quantization width by multiplying said standard deviation by a watermark embedding strength.

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5. A method for reading digital watermark data embedded in digital data contents, said method comprising the steps of:

25 receiving said digital data contents; dividing said digital data contents into block data;

obtaining a frequency coefficient of said block data; and

30 generating digital watermark data from said frequency coefficient by using a quantization width corresponding to said frequency coefficient, said quantization width being obtained beforehand according to a manipulation method of said digital data contents.

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6. The method as claimed in claim 5,  
wherein said quantization width is obtained by a  
method comprising the steps of:

- 5        dividing first digital data contents into  
            one or a plurality of first block data;
- dividing second digital data contents into  
            one or a plurality of second block data, said second  
            digital data contents being obtained by manipulating
- 10      said first digital data contents with a  
            predetermined manipulation method;
- transforming said first block data and  
            said second block data into first frequency  
            coefficients and second frequency coefficients
- 15      respectively by applying an orthogonal transform;  
      obtaining difference values between said  
            first frequency coefficients and said second  
            frequency coefficients for each frequency  
            coefficient;
- 20      calculating a standard deviation of  
            distribution of said difference values; and  
      obtaining said quantization width by  
            multiplying said standard deviation by a watermark  
            embedding strength.

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7. An apparatus for embedding digital  
30 watermark data in digital data contents, said  
apparatus comprising:

- means for receiving said digital data  
            contents and said digital watermark data;
- means for dividing said digital data  
            contents into block data;
- 35      means for obtaining a frequency  
            coefficient of said block data;

means for obtaining a complexity of said block data;

5 means for obtaining an amount of transformation of said frequency coefficient from said complexity and said digital watermark data by using a quantization width;

means for embedding said digital watermark data in said digital data contents by transforming said frequency coefficient by said amount; and

10 means for generating watermarked digital data contents.

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8. The apparatus as claimed in claim 7, said means for obtaining said complexity of said block data comprising:

20 means for transforming said block data, by applying a wavelet transform, into coefficients of said wavelet transform, and

means for obtaining said complexity on the basis of the number of high frequency coefficients in said coefficients of said wavelet transform, each 25 of said high frequency coefficients exceeding a threshold.

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9. An apparatus for embedding digital watermark data in digital data contents, said apparatus comprising:

35 means for receiving said digital data contents and said digital watermark data;

means for dividing said digital data contents into block data;

means for obtaining a frequency coefficient of said block data;

means for obtaining an amount of transformation of said frequency coefficient from

5 said digital watermark data by using a quantization width corresponding to said frequency coefficient, said quantization width being obtained beforehand according to a manipulation method of said digital data contents;

10 means for embedding said digital watermark data in said digital data contents by transforming said frequency coefficient by said amount; and

means for generating watermarked digital data contents.

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10. The apparatus as claimed in claim 9,

20 wherein said quantization width is obtained by means comprising:

means for dividing first digital data contents into one or a plurality of first block data;

25 means for dividing second digital data contents into one or a plurality of second block data, said second digital data contents being obtained by manipulating said first digital data contents with a predetermined manipulation method;

30 means for transforming said first block data and said second block data into first frequency coefficients and second frequency coefficients respectively by applying an orthogonal transform;

means for obtaining difference values

35 between said first frequency coefficients and said second frequency coefficients for each frequency coefficient;

means for calculating a standard deviation  
of distribution of said difference values; and  
means for obtaining said quantization  
width by multiplying said standard deviation by a  
5 watermark embedding strength.

10           11. An apparatus for reading digital  
watermark data embedded in digital data contents,  
said apparatus comprising:

means for receiving said digital data  
contents;

15           means for dividing said digital data  
contents into block data;

means for obtaining a frequency  
coefficient of said block data; and

20           means for generating digital watermark  
data from said frequency coefficient by using a  
quantization width corresponding to said frequency  
coefficient, said quantization width being obtained  
beforehand according to a manipulation method of  
said digital data contents.

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30           12. The apparatus as claimed in claim 11,  
wherein said quantization width is obtained by means  
comprising:

means for dividing first digital data  
contents into one or a plurality of first block  
data;

35           means for dividing second digital data  
contents into one or a plurality of second block  
data, said second digital data contents being

obtained by manipulating said first digital data contents with a predetermined manipulation method;

means for transforming said first block data and said second block data into first frequency  
5 coefficients and second frequency coefficients respectively by applying an orthogonal transform;  
means for obtaining difference values between said first frequency coefficients and said second frequency coefficients for each frequency coefficient;

10 means for calculating a standard deviation of distribution of said difference values; and  
means for obtaining said quantization width by multiplying said standard deviation by a  
15 watermark embedding strength.

20 13. An integrated circuit for embedding digital watermark data in digital data contents, said integrated circuit comprising:

means for receiving said digital data contents and said digital watermark data;  
25 means for dividing said digital data contents into block data;  
means for obtaining a frequency coefficient of said block data;  
means for obtaining a complexity of said  
30 block data;  
means for obtaining an amount of transformation of said frequency coefficient from said complexity and said digital watermark data by using a quantization width;  
35 means for embedding said digital watermark data in said digital data contents by transforming said frequency coefficient by said amount; and

means for generating watermarked digital data contents.

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14. The integrated circuit as claimed in claim 13, said means for obtaining said complexity of said block data comprising:

10       means for transforming said block data, by applying a wavelet transform, into coefficients of said wavelet transform, and

15       means for obtaining said complexity on the basis of the number of high frequency coefficients in said coefficients of said wavelet transform, each of said high frequency coefficients exceeding a threshold.

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15. An integrated circuit for embedding digital watermark data in digital data contents, said integrated circuit comprising:

25       means for receiving said digital data contents and said digital watermark data;

          means for dividing said digital data contents into block data;

30       means for obtaining a frequency coefficient of said block data;

          means for obtaining an amount of transformation of said frequency coefficient from said digital watermark data by using a quantization width corresponding to said frequency coefficient, 35       said quantization width being obtained beforehand according to a manipulation method of said digital data contents;

means for embedding said digital watermark data in said digital data contents by transforming said frequency coefficient by said amount; and  
means for generating watermarked digital  
5 data contents.

10 16. The integrated circuit as claimed in claim 15, wherein said quantization width is obtained by means comprising:

means for dividing first digital data contents into one or a plurality of first block  
15 data;

means for dividing second digital data contents into one or a plurality of second block data, said second digital data contents being obtained by manipulating said first digital data  
20 contents with a predetermined manipulation method;

means for transforming said first block data and said second block data into first frequency coefficients and second frequency coefficients respectively by applying an orthogonal transform;

25 means for obtaining difference values between said first frequency coefficients and said second frequency coefficients for each frequency coefficient;

means for calculating a standard deviation  
30 of distribution of said difference values; and

means for obtaining said quantization width by multiplying said standard deviation by a watermark embedding strength.

17. An integrated circuit for reading  
digital watermark data embedded in digital data  
contents, said integrated circuit comprising:  
means for receiving said digital data  
5 contents;  
means for dividing said digital data  
contents into block data;  
means for obtaining a frequency  
coefficient of said block data; and  
10 means for generating digital watermark  
data from said frequency coefficient by using a  
quantization width corresponding to said frequency  
coefficient, said quantization width being obtained  
beforehand according to a manipulation method of  
15 said digital data contents.

20 18. The integrated circuit as claimed in  
claim 17, wherein said quantization width is  
obtained by means comprising:  
means for dividing first digital data  
contents into one or a plurality of first block  
25 data;  
means for dividing second digital data  
contents into one or a plurality of second block  
data, said second digital data contents being  
obtained by manipulating said first digital data  
30 contents with a predetermined manipulation method;  
means for transforming said first block  
data and said second block data into first frequency  
coefficients and second frequency coefficients  
respectively by applying an orthogonal transform;  
35 means for obtaining difference values  
between said first frequency coefficients and said  
second frequency coefficients for each frequency

coefficient;  
means for calculating a standard deviation  
of distribution of said difference values; and  
means for obtaining said quantization  
5 width by multiplying said standard deviation by a  
watermark embedding strength.

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19. A computer readable medium storing  
program code for causing a computer system to embed  
digital watermark data in digital data contents,  
said computer readable medium comprising:  
15 program code means for receiving said  
digital data contents and said digital watermark  
data;  
program code means for dividing said  
digital data contents into block data;  
20 program code means for obtaining a  
frequency coefficient of said block data;  
program code means for obtaining a  
complexity of said block data;  
program code means for obtaining an amount  
25 of transformation of said frequency coefficient from  
said complexity and said digital watermark data by  
using a quantization width;  
program code means for embedding said  
digital watermark data in said digital data contents  
30 by transforming said frequency coefficient by said  
amount; and  
program code means for generating  
watermarked digital data contents.

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20. The computer readable medium as claimed in claim 19, said program code means for obtaining said complexity of said block data comprising:

- 5           program code means for transforming said block data, by applying a wavelet transform, into coefficients of said wavelet transform, and
- program code means for obtaining said complexity on the basis of the number of high
- 10          frequency coefficients in said coefficients of said wavelet transform, each of said high frequency coefficients exceeding a threshold.

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21. A computer readable medium storing program code for causing a computer system to embed digital watermark data in digital data contents,

- 20          said computer readable medium comprising:
  - program code means for receiving said digital data contents and said digital watermark data;
  - program code means for dividing said digital data contents into block data;
  - program code means for obtaining a frequency coefficient of said block data;
  - program code means for obtaining an amount of transformation of said frequency coefficient from
  - 30          said digital watermark data by using a quantization width corresponding to said frequency coefficient, said quantization width being obtained beforehand according to a manipulation method of said digital data contents;
  - program code means for embedding said digital watermark data in said digital data contents by transforming said frequency coefficient by said

amount; and

program code means for generating  
watermarked digital data contents.

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22. The computer readable medium as  
claimed in claim 21, wherein said quantization width  
10 is obtained by program code means comprising:  
program code means for dividing first  
digital data contents into one or a plurality of  
first block data;  
program code means for dividing second  
15 digital data contents into one or a plurality of  
second block data, said second digital data contents  
being obtained by manipulating said first digital  
data contents with a predetermined manipulation  
method;  
20 program code means for transforming said  
first block data and said second block data into  
first frequency coefficients and second frequency  
coefficients respectively by applying an orthogonal  
transform;  
25 program code means for obtaining  
difference values between said first frequency  
coefficients and said second frequency coefficients  
for each frequency coefficient;  
program code means for calculating a  
30 standard deviation of distribution of said  
difference values; and  
program code means for obtaining said  
quantization width by multiplying said standard  
deviation by a watermark embedding strength.

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23. A computer readable medium storing  
program code for causing a computer system to read  
digital watermark data embedded in digital data  
5 contents, said computer readable medium comprising:  
    program code means for receiving said  
    digital data contents;  
    program code means for dividing said  
    digital data contents into block data;  
10     program code means for obtaining a  
    frequency coefficient of said block data; and  
    program code means for generating digital  
    watermark data from said frequency coefficient by  
    using a quantization width corresponding to said  
15 frequency coefficient, said quantization width being  
    obtained beforehand according to a manipulation  
    method of said digital data contents.

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24. The computer readable medium as  
claimed in claim 23, wherein said quantization width  
is obtained by program code means comprising:  
25     program code means for dividing first  
    digital data contents into one or a plurality of  
    first block data;  
    program code means for dividing second  
    digital data contents into one or a plurality of  
30     second block data, said second digital data contents  
    being obtained by manipulating said first digital  
    data contents with a predetermined manipulation  
    method;  
    program code means for transforming said  
35     first block data and said second block data into  
    first frequency coefficients and second frequency  
    coefficients respectively by applying an orthogonal

transform;

program code means for obtaining difference values between said first frequency coefficients and said second frequency coefficients  
5 for each frequency coefficient;

program code means for calculating a standard deviation of distribution of said difference values; and

10 program code means for obtaining said quantization width by multiplying said standard deviation by a watermark embedding strength.

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25. A method for reading digital watermark data embedded in digital data contents, said method comprising the steps of:

receiving said digital data contents;  
20 reading a bit sequence from said digital data contents;

calculating a probability of reading a bit '1' or a bit '0' in said bit sequence by using a test method on the basis of binary distribution;

25 determining the presence or absence of digital watermark data according to said probability; and

reconstituting and generating said digital watermark data from said bit sequence.

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26. The method as claimed in claim 25,  
35 further comprising the steps of:

determining threshold  $\alpha$  of reliability of digital watermark data which is read;

obtaining a binary distribution function  $F(x)$  which represents a probability that a number  $x$  of '1' bits or '0' bits are included in a bit sequence which is read at random from digital data contents, said binary distribution function  $F(x)$  being obtained by using a probability  $q$  of reading '1' or '0' in said bit sequence and a repeating number of embedding each bit of digital watermark data;

10           reading an  $i$ th digital watermark sequence of said digital watermark data from a digital watermark area of said digital data contents;

              calculating the number  $k_i$  of '1' or '0' included in said digital watermark sequence;

15           calculating a probability  $F(k_i)$  by using said binary distribution function  $F(x)$ ; and

              reconstituting '1' or '0' from  $i$ th digital watermark data  $w_i$  if  $F(k_i) > \alpha$ , reconstituting '0' or '1' from  $i$ th digital watermark data  $w_i$  if  $1-F(k_i) > \alpha$ , and determining that there is no watermark data or the presence is unknown if both of  $F(k_i) > \alpha$  and  $1-F(k_i) > \alpha$  are not satisfied.

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27. The method as claimed in claim 26, further comprising the steps of:

              outputting  $F(k_i)$  as reliability if said 30 reconstituted digital watermark data  $w_i$  is '1'; and

              outputting  $1-F(k_i)$  as the reliability if said reconstituted digital watermark data  $w_i$  is '0'.

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28. The method as claimed in claim 25,

further comprising the steps of:

determining a threshold  $\alpha$  of reliability of digital watermark data which is read;

obtaining a binary distribution function  
5  $F(x)$  which represents a probability that a number  $x$  of '1' bits or '0' bits are included in a bit sequence which is read at random from digital data contents, said binary distribution function  $F(x)$  being obtained by using a probability  $q$  of reading  
10 '1' or '0' in said bit sequence and a repeating number of embedding each bit of digital watermark data;

reading an  $i$ th digital watermark sequence of said digital watermark data from a digital  
15 watermark area of said digital data contents;

checking whether a probability that said digital watermark sequence is digital watermark data exceeds said threshold  $\alpha$  by using said binary distribution function  $F(x)$ ; and

20 reconstituting digital watermark data from said digital watermark sequence by using majority decision processing if said probability exceeds  $\alpha$ , and determining that there is no watermark data or the presence is unknown if said probability does not  
25 exceed  $\alpha$ .

30 29. The method as claimed in claim 28, further comprising a step of outputting said probability that said digital watermark sequence is digital watermark data.

30. The method as claimed in claim 25, if  
a data sequence which is embedded as said digital  
watermark data is modulated by a pseudo-random  
sequence, said method further comprising the steps  
5 of:

demodulating said bit sequence by said  
pseudo-random sequence; and  
reconstituting digital watermark data from  
said demodulated bit sequence.

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31. The method as claimed in claim 25, if  
15 a data sequence which is embedded as said digital  
watermark data is modulated by a pseudo-random  
sequence, said method further comprising the steps  
of:

determining a threshold  $\alpha$  of reliability  
20 of digital watermark data which is read;  
obtaining a binary distribution function  
 $F(x)$  which represents a probability that a number of  
 $x$  of '1' bits or '0' bits are included in a bit  
sequence which is read at random from digital data  
25 contents, said binary distribution function  $F(x)$   
being obtained by using a probability  $q$  of reading  
'1' or '0' in said bit sequence and a repeating  
number of embedding each bit of digital watermark  
data;

30 reading an  $i$ th digital watermark sequence  
of said digital watermark data from a digital  
watermark area of said digital data contents;

demodulating said digital watermark  
sequence by said pseudo-random sequence;

35 assigning  $1/2$  to said probability  $q$ ;  
obtaining a maximum number  $x_0$  which  
satisfies  $0 \leq F(x=x_0) \leq 1 - \alpha$  and a minimum number  $x_1$

which satisfies  $\alpha \leq F(x=x_1) \leq 1$ ;  
obtaining the number  $k_i$  of '1' or '0'  
included in said  $i$ th digital watermark sequence; and  
reconstituting  $i$ th digital watermark data  
5  $w_i$  as '0' or '1' if  $k_i \leq x_0$ , and reconstituting said  
 $i$ th digital watermark data  $w_i$  as '1' or '0' if  $k_i \geq x_1$ .

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32. The method as claimed in claim 25, if  
a data sequence which is embedded as said digital  
watermark data is modulated by a pseudo-random  
sequence, said method further comprising the steps  
15 of:

determining a threshold  $\alpha$  of reliability  
of digital watermark data which is read;  
obtaining a binary distribution function  
20  $F(x)$  which represents a probability that  $x$  of '1'  
bits or '0' bits are included in a bit sequence  
which is read at random from digital data contents,  
said binary distribution function  $F(x)$  being  
obtained by using a probability  $q$  of reading '1' or  
'0' in said bit sequence and a repeating number  $t$  of  
25 embedding each bit of digital watermark data;  
reading an  $i$ th digital watermark sequence  
of said digital watermark data from a digital  
watermark area of said digital data contents;  
demodulating said digital watermark  
30 sequence by said pseudo-random sequence;  
assigning 1/2 to said probability  $q$ ;  
obtaining  $x_0$  or  $x_1$  which satisfies  $0 \leq$   
 $F(x=x_0) \leq 1 - \alpha$  or  $\alpha \leq F(x=x_1) \leq 1$ ;  
determining whether a value is equal to or  
35 less than  $x_0$  or equal to or more than  $x_1$ , said value  
being a mean value of absolute values of a  
difference between the number of '0' or '1' included

in said ith digital watermark sequence and a central value  $q \times t$  of a binary distribution;

5 reconstituting digital watermark data by performing majority decision processing for said ith digital watermark sequence if said value is equal to or less than  $x_0$  or equal to or more than  $x_1$ ; and

10 determining that there is no digital watermark data or the presence is unknown if said value is not equal to or less than  $x_0$  or equal to or more than  $x_1$ .

15 33. The method as claimed in claim 32,  
further comprising the steps of:

20 calculating a value of said binary distribution function  $F(z)$ ,  $z$  being said mean value obtained from the number of '0' or '1' included in said ith digital watermark sequence and said central value  $q \times t$ ; and

outputting said value of  $F(z)$  as reliability of digital watermark data.

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34. An apparatus for reading digital watermark data embedded in digital data contents,  
30 said apparatus comprising:

means for receiving said digital data contents;

means for reading a bit sequence from said digital data contents;

35 means for calculating a probability of reading a bit '1' or a bit '0' in said bit sequence by using a test method on the basis of binary

distribution;

means for determining the presence or absence of digital watermark data according to said probability; and

5 means for reconstituting said digital watermark data from said bit sequence.

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35. The apparatus as claimed in claim 34, further comprising:

means for obtaining a binary distribution function  $F(x)$  which represents a probability that a number  $x$  of '1' bits or '0' bits are included in a bit sequence which is read at random from digital data contents, said binary distribution function  $F(x)$  being obtained by using a probability  $q$  of reading '1' or '0' in said bit sequence and a repeating number of embedding each bit of digital watermark data;

means for reading an  $i$ th digital watermark sequence of said digital watermark data from a digital watermark area of said digital data contents;

means for calculating the number  $k_i$  of '1' or '0' included in said digital watermark sequence; means for calculating a probability  $F(k_i)$  by using said binary distribution function  $F(x)$ ; and means for reconstituting '1' or '0' from  $i$ th digital watermark data  $w_i$  if  $F(k_i) > \alpha$ , reconstituting '0' or '1' from  $i$ th digital watermark data  $w_i$  if  $1-F(k_i) > \alpha$ , and, determining that there is no watermark data or the presence is unknown if both of  $F(k_i) > \alpha$  and  $1-F(k_i) > \alpha$  are not satisfied,  $\alpha$  being a threshold of reliability of digital watermark data which is read.

5               36. The apparatus as claimed in claim 35,  
further comprising:

              means for outputting  $F(k_i)$  as reliability  
if said reconstituted digital watermark data  $w_i$  is  
'1'; and

10              means for outputting  $1-F(k_i)$  as  
reliability if said reconstituted digital watermark  
data  $w_i$  is '0'.

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              37. The apparatus as claimed in claim 34,  
further comprising:

              means for obtaining a binary distribution  
20       function  $F(x)$  which represents a probability that a  
number  $x$  of '1' bits or '0' bits are included in a  
bit sequence which is read at random from digital  
data contents, said binary distribution function  
 $F(x)$  being obtained by using a probability  $q$  of  
25       reading '1' or '0' in said bit sequence and a  
repeating number of embedding each bit of digital  
watermark data;

              means for reading an  $i$ th digital watermark  
sequence of said digital watermark data from a  
30       digital watermark area of said digital data  
contents;

              means for checking whether a probability  
that said digital watermark sequence is digital  
watermark data exceeds said threshold  $\alpha$  by using  
35       said binary distribution function  $F(x)$ ,  $\alpha$  being a  
threshold of reliability of digital watermark data  
which is read; and

means for reconstituting and generating digital watermark data from said digital watermark sequence by using majority decision processing if said probability exceeds  $\alpha$ , and, determining that  
5 there is no watermark data or the presence is unknown if said probability does not exceed  $\alpha$ .

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38. The apparatus as claimed in claim 37, further comprising means for outputting said probability that said digital watermark sequence is digital watermark data.

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39. The apparatus as claimed in claim 34,  
20 if a data sequence which is embedded as said digital watermark data is modulated by a pseudo-random sequence, said apparatus further comprising:  
means for demodulating said bit sequence by said pseudo-random sequence; and  
25 means for reconstituting digital watermark data from said demodulated bit sequence.

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40. The apparatus as claimed in claim 34, if a data sequence which is embedded as said digital watermark data is modulated by a pseudo-random sequence, said apparatus further comprising:  
35 means for obtaining a binary distribution function  $F(x)$  which represents a probability that a number  $x$  of '1' bits or '0' bits are included in a

bit sequence which is read at random from digital data contents, said binary distribution function  $F(x)$  being obtained by using a probability  $q$  of reading '1' or '0' in said bit sequence and a repeating number of embedding each bit of digital watermark data;

means for reading an  $i$ th digital watermark sequence of said digital watermark data from a digital watermark area of said digital data contents;

means for demodulating said digital watermark sequence by said pseudo-random sequence;

means for assigning  $1/2$  to said probability  $q$ ;

means for obtaining a maximum number  $x_0$  which satisfies  $0 \leq F(x=x_0) \leq 1-\alpha$  and a minimum number  $x_1$  which satisfies  $\alpha \leq F(x=x_1) \leq 1$ ,  $\alpha$  being a threshold of reliability of digital watermark data which is read;

means for obtaining the number  $k_i$  of '1' or '0' included in said  $i$ th digital watermark sequence; and

means for reconstituting  $i$ th digital watermark data  $w_i$  as '0' or '1' if  $k_i \leq x_0$ , and, reconstituting said  $i$ th digital watermark data  $w_i$  as '1' or '0' if  $k_i \geq x_1$ .

30                  41. The apparatus as claimed in claim 34, if a data sequence which is embedded as said digital watermark data is modulated by a pseudo-random sequence, said apparatus further comprising:

35                  means for obtaining a binary distribution function  $F(x)$  which represents a probability that a number  $x$  of '1' bits or '0' bits are included in a

bit sequence which is read at random from digital data contents, said binary distribution function  $F(x)$  being obtained by using a probability  $q$  of reading '1' or '0' in said bit sequence and a repeating number  $t$  of embedding each bit of digital watermark data;

5 means for reading an  $i$ th digital watermark sequence of said digital watermark data from a digital watermark area of said digital data contents;

10 means for demodulating said digital watermark sequence by said pseudo-random sequence;

means for assigning  $1/2$  to said probability  $q$ ;

15 means for obtaining  $x_0$  or  $x_1$  which satisfies  $0 \leq F(x=x_0) \leq 1-\alpha$  or  $\alpha \leq F(x=x_1) \leq 1$ ,  $\alpha$  being a threshold of reliability of digital watermark data which is read;

20 means for determining whether a value is equal to or less than  $x_0$  or equal to or more than  $x_1$ , said value being a mean value of absolute values of a difference between the number of '0' or '1' included in said  $i$ th digital watermark sequence and a central value  $q \times t$  of a binary distribution;

25 means for reconstituting digital watermark data by performing majority decision processing for said  $i$ th digital watermark sequence if said value is equal to or less than  $x_0$  or equal to or more than  $x_1$ ; and

30 means for determining that there is no digital watermark data or the presence is unknown if said value is not equal to or less than  $x_0$  or equal to or more than  $x_1$ .

42. The apparatus as claimed in claim 41,  
further comprising:

means for calculating a value of said  
binary distribution function  $F(z)$ ,  $z$  being said mean  
5 value obtained from the number of '0' or '1'  
included in said  $i$ th digital watermark sequence and  
said central value  $q \times t$ ; and

means for outputting said value of  $F(z)$  as  
reliability of digital watermark data.

10

43. An integrated circuit for reading  
15 digital watermark data embedded in digital data  
contents, said integrated circuit comprising:

means for receiving said digital data  
contents;

means for reading a bit sequence from said  
20 digital data contents;

means for calculating a probability of  
reading a bit '1' or a bit '0' in said bit sequence  
by using a test method on the basis of binary  
distribution;

25 means for determining the presence or  
absence of digital watermark data according to said  
probability; and

means for reconstituting and generating  
said digital watermark data from said bit sequence.

30

44. The integrated circuit as claimed in  
35 claim 43, further comprising:

means for obtaining a binary distribution  
function  $F(x)$  which represents a probability that a

number  $x$  of '1' bits or '0' bits are included in a bit sequence which is read at random from digital data contents, said binary distribution function  $F(x)$  being obtained by using a probability  $q$  of  
5 reading '1' or '0' in said bit sequence and a repeating number of embedding each bit of digital watermark data;

means for reading an  $i$ th digital watermark sequence of said digital watermark data from a  
10 digital watermark area of said digital data contents;

means for calculating the number  $k_i$  of '1' or '0' included in said digital watermark sequence;

means for calculating a probability  $F(k_i)$   
15 by using said binary distribution function  $F(x)$ ; and means for reconstituting '1' or '0' from  $i$ th digital watermark data  $w_i$  if  $F(k_i) > \alpha$ , reconstituting '0' or '1' from  $i$ th digital watermark data  $w_i$  if  $1-F(k_i) > \alpha$ , and determining that there  
20 is no watermark data or the presence is unknown if both of  $F(k_i) > \alpha$  and  $1-F(k_i) > \alpha$  are not satisfied,  $\alpha$  being a threshold of reliability of digital watermark data which is read.

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45. The integrated circuit as claimed in claim 44, further comprising:  
30 means for outputting  $F(k_i)$  as reliability if said reconstituted digital watermark data  $w_i$  is '1'; and  
means for outputting  $1-F(k_i)$  as reliability if said reconstituted digital watermark data  $w_i$  is '0'.  
35

46. The integrated circuit as claimed in  
claim 43, further comprising:

5 means for obtaining a binary distribution  
function  $F(x)$  which represents a probability that a  
number of  $x$  of '1' bits or '0' bits are included in  
a bit sequence which is read at random from digital  
data contents, said binary distribution function  
10  $F(x)$  being obtained by using a probability  $q$  of  
reading '1' or '0' in said bit sequence and a  
repeating number of embedding each bit of digital  
watermark data;

means for reading an  $i$ th digital watermark  
15 sequence of said digital watermark data from a  
digital watermark area of said digital data  
contents;

means for checking whether a probability  
that said digital watermark sequence is digital  
20 watermark data exceeds said threshold  $\alpha$  by using  
said binary distribution function  $F(x)$ ,  $\alpha$  being a  
threshold of reliability of digital watermark data  
which is read; and

means for reconstituting and generating  
25 digital watermark data from said digital watermark  
sequence by using majority decision processing if  
said probability exceeds  $\alpha$ , and, determining that  
there is no watermark data or the presence is  
unknown if said probability does not exceed  $\alpha$ .

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47. The integrated circuit as claimed in  
35 claim 46, further comprising means for outputting  
said probability that said digital watermark  
sequence is digital watermark data.

5       48. The integrated circuit as claimed in  
claim 43, if a data sequence which is embedded as  
said digital watermark data is modulated by a  
pseudo-random sequence, said integrated circuit  
further comprising:  
10      means for demodulating said bit sequence  
by said pseudo-random sequence; and  
means for reconstituting digital watermark  
data from said demodulated bit sequence.

15      49. The integrated circuit as claimed in  
claim 43, if a data sequence which is embedded as  
said digital watermark data is modulated by a  
pseudo-random sequence, said integrated circuit  
further comprising:  
20      means for obtaining a binary distribution  
function  $F(x)$  which represents a probability that a  
number  $x$  of '1' bits or '0' bits are included in a  
bit sequence which is read at random from digital  
data contents, said binary distribution function  
25       $F(x)$  being obtained by using a probability  $q$  of  
reading '1' or '0' in said bit sequence and a  
repeating number of embedding each bit of digital  
watermark data;  
30      means for reading an  $i$ th digital watermark  
sequence of said digital watermark data from a  
digital watermark area of said digital data  
contents;  
35      means for demodulating said digital  
watermark sequence by said pseudo-random sequence;

means for assigning 1/2 to said probability q;

5 means for obtaining a maximum number  $x_0$ , which satisfies  $0 \leq F(x=x_0) \leq 1-\alpha$  and a minimum number  $x_1$  which satisfies  $\alpha \leq F(x=x_1) \leq 1$ ,  $\alpha$  being a threshold of reliability of digital watermark data which is read; and

10 means for obtaining the number  $k_i$  of '1' or '0' included in said ith digital watermark sequence;

15 means for reconstituting ith digital watermark data  $w_i$  as '0' or '1' if  $k_i \leq x_0$ , and, reconstituting said ith digital watermark data  $w_i$  as '1' or '0' if  $k_i \geq x_1$ .

50. The integrated circuit as claimed in  
20 claim 43, if a data sequence which is embedded as said digital watermark data is modulated by a pseudo-random sequence, said integrated circuit further comprising:

25 means for obtaining a binary distribution function  $F(x)$  which represents a probability that a number  $x$  of '1' bits or '0' bits are included in a bit sequence which is read at random from digital data contents, said binary distribution function  $F(x)$  being obtained by using a probability  $q$  of  
30 reading '1' or '0' in said bit sequence and a repeating number  $t$  of embedding each bit of digital watermark data;

35 means for reading an ith digital watermark sequence of said digital watermark data from a digital watermark area of said digital data contents;

means for demodulating said digital

watermark sequence by said pseudo-random sequence;  
means for assigning 1/2 to said  
probability q;  
means for obtaining  $x_0$  or  $x_1$  which  
5 satisfies  $0 \leq F(x=x_0) \leq 1-\alpha$  or  $\alpha \leq F(x=x_1) \leq 1$ ,  $\alpha$  being a  
threshold of reliability of digital watermark data  
which is read;  
means for determining whether a value is  
equal to or less than  $x_0$  or equal to or more than  $x_1$ ,  
10 said value being a mean value of absolute values of  
a difference between the number of '0' or '1'  
included in said ith digital watermark sequence and  
a central value  $q \times t$  of a binary distribution;  
means for reconstituting digital watermark  
15 data by performing majority decision processing for  
said ith digital watermark sequence if said value is  
equal to or less than  $x_0$  or equal to or more than  
 $x_1$ ; and  
means for determining that there is no  
20 digital watermark data or the presence is unknown if  
said value is not equal to or less than  $x_0$  or equal  
to or more than  $x_1$ .

25

51. The integrated circuit as claimed in  
claim 50, further comprising:  
means for calculating a value of said  
30 binary distribution function  $F(z)$ ,  $z$  being said mean  
value obtained from the number of '0' or '1'  
included in said ith digital watermark sequence and  
said central value  $q \times t$ ; and  
means for outputting said value of  $F(z)$  as  
35 reliability of digital watermark data.

52. A computer readable medium storing  
program code for causing a computer system to read  
5 digital watermark data embedded in digital data  
contents, said computer readable medium comprising:  
          program code means for receiving said  
digital data contents;  
          program code means for reading a bit  
10 sequence from said digital data contents;  
          program code means for calculating a  
probability of reading a bit '1' or a bit '0' in  
said bit sequence by using a test method on the  
basis of binary distribution;  
15          program code means for determining the  
presence or absence of digital watermark data  
according to said probability; and  
          program code means for reconstituting and  
generating said digital watermark data from said bit  
20 sequence.

25          53. The computer readable medium as  
claimed in claim 52, further comprising:  
          program code means for obtaining a binary  
distribution function  $F(x)$  which represents a  
probability that a number  $x$  of '1' bits or '0' bits  
30 are included in a bit sequence which is read at  
random from digital data contents, said binary  
distribution function  $F(x)$  being obtained by using a  
probability  $q$  of reading '1' or '0' in said bit  
sequence and a repeating number of embedding each  
35 bit of digital watermark data;  
          program code means for reading an  $i$ th  
digital watermark sequence of said digital watermark

data from a digital watermark area of said digital data contents;

5 program code means for calculating the number  $k_i$  of '1' or '0' included in said digital watermark sequence; and

program code means for calculating a probability  $F(k_i)$  by using said binary distribution function  $F(x)$ ;

10 program code means for reconstituting '1' or '0' from  $i$ th digital watermark data  $w_i$  if  $F(k_i) > \alpha$ , reconstituting '0' or '1' from  $i$ th digital watermark data  $w_i$  if  $1-F(k_i) > \alpha$ , and, determining that there is no watermark data or the presence is unknown if both of  $F(k_i) > \alpha$  and  $1-F(k_i) > \alpha$  are 15 not satisfied,  $\alpha$  being a threshold of reliability of digital watermark data which is read.

20

54. The computer readable medium as claimed in claim 53, further comprising:

25 program code means for outputting  $F(k_i)$  as reliability if said reconstituted digital watermark data  $w_i$  is '1'; and

program code means for outputting  $1-F(k_i)$  as reliability if said reconstituted digital watermark data  $w_i$  is '0'.

30

55. The computer readable medium as claimed in claim 52, further comprising:

35 program code means for obtaining a binary distribution function  $F(x)$  which represents a probability that a number  $x$  of '1' bits or '0' bits

are included in a bit sequence which is read at random from digital data contents, said binary distribution function  $F(x)$  being obtained by using a probability  $q$  of reading '1' or '0' in said bit sequence and a repeating number of embedding each bit of digital watermark data;

5 program code means for reading an  $i$ th digital watermark sequence of said digital watermark data from a digital watermark area of said digital data contents;

10 program code means for checking whether a probability that said digital watermark sequence is digital watermark data exceeds said threshold  $\alpha$  by using said binary distribution function  $F(x)$ ,  $\alpha$  being a threshold of reliability of digital watermark data which is read; and

15 program code means for reconstituting and generating digital watermark data from said digital watermark sequence by using majority decision processing if said probability exceeds  $\alpha$ , and determining that there is no watermark data or the presence is unknown if said probability does not exceed  $\alpha$ .

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56. The computer readable medium as claimed in claim 55, further comprising program code means for outputting said probability that said digital watermark sequence is digital watermark data as reliability of said reconstituted digital watermark data.

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57. The computer readable medium as  
claimed in claim 52, if a data sequence which is  
embedded as said digital watermark data is modulated  
by a pseudo-random sequence, said computer readable  
5 medium further comprising:

program code means for demodulating said  
bit sequence by said pseudo-random sequence; and  
10 program code means for reconstituting  
digital watermark data from said demodulated bit  
sequence.

15 58. The computer readable medium as  
claimed in claim 52, if data sequence which is  
embedded as said digital watermark data is modulated  
by a pseudo-random sequence, said computer readable  
medium further comprising:

20 program code means for obtaining a binary  
distribution function  $F(x)$  which represents a  
probability that a number  $x$  of '1' bits or '0' bits  
are included in a bit sequence which is read at  
random from digital data contents, said binary  
25 distribution function  $F(x)$  being obtained by using a  
probability  $q$  of reading '1' or '0' in said bit  
sequence and a repeating number of embedding each  
bit of digital watermark data;

30 program code means for reading an  $i$ th  
digital watermark sequence of said digital watermark  
data from a digital watermark area of said digital  
data contents;

35 program code means for demodulating said  
digital watermark sequence by said pseudo-random  
sequence;

program code means for assigning 1/2 to  
said probability  $q$ ;

program code means for obtaining a maximum number  $x_0$  which satisfies  $0 \leq F(x=x_0) \leq 1-\alpha$  and a minimum number  $x_1$  which satisfies  $\alpha \leq F(x=x_1) \leq 1$ ,  $\alpha$  being a threshold of reliability of digital watermark data which is read;

program code means for obtaining the number  $k_i$  of '1' or '0' included in said ith digital watermark sequence; and

program code means for reconstituting ith digital watermark data  $w_i$  as '0' or '1' if  $k_i \leq x_0$ , and reconstituting said ith digital watermark data  $w_i$  as '1' or '0' if  $k_i \geq x_1$ .

15

59. The computer readable medium as claimed in claim 52, if a data sequence which is embedded as said digital watermark data is modulated by a pseudo-random sequence, said computer readable medium further comprising:

program code means for obtaining a binary distribution function  $F(x)$  which represents a probability that a number  $x$  of '1' bits or '0' bits are included in a bit sequence which is read at random from digital data contents, said binary distribution function  $F(x)$  being obtained by using a probability  $q$  of reading '1' or '0' in said bit sequence and a repeating number  $t$  of embedding each bit of digital watermark data;

program code means for reading an ith digital watermark sequence of said digital watermark data from a digital watermark area of said digital data contents;

35 program code means for demodulating said digital watermark sequence by said pseudo-random sequence;

program code means for assigning 1/2 to said probability q;

5 program code means for obtaining  $x_0$  or  $x_1$  which satisfies  $0 \leq F(x=x_0) \leq 1-\alpha$  or  $\alpha \leq F(x=x_1) \leq 1$ ,  $\alpha$  being a threshold of reliability of digital watermark data which is read;

10 program code means for determining whether a value is equal to or less than  $x_0$  or equal to or more than  $x_1$ , said value being a mean value of absolute values of a difference between the number of '0' or '1' included in said ith digital watermark sequence and a central value  $q \times t$  of a binary distribution;

15 program code means for reconstituting digital watermark data by performing majority decision processing for said ith digital watermark sequence if said value is equal to or less than  $x_0$  or equal to or more than  $x_1$ ; and

20 program code means for determining that there is no digital watermark data or the presence is unknown if said value is not equal to or less than  $x_0$  or equal to or more than  $x_1$ .

25

60. The computer readable medium as claimed in claim 59, further comprising:

30 program code means for calculating a value of said binary distribution function  $F(z)$ , z being said mean value obtained from the number of '0' or '1' included in said ith digital watermark sequence and said central value  $q \times t$ ; and

35 program code means for outputting said value of  $F(z)$  as reliability of digital watermark data.

61. A method for reading digital watermark  
5 data from digital data contents in which each bit of  
digital watermark data is embedded a plurality of  
times, said method comprising the steps of:  
receiving digital data contents;  
reading a digital watermark sequence from  
10 said digital data contents;  
performing soft decision in code theory by  
assigning weights to said digital watermark sequence  
with a weighting function; and  
reconstituting and generating digital  
15 watermark data from said digital watermark sequence.

20 62. The method as claimed in claim 61,  
wherein said weighting function is a distribution  
function obtained by a method comprising the steps  
of:  
dividing first digital data contents into  
25 one or a plurality of first block data;  
dividing second digital data contents into  
one or a plurality of second block data, said second  
digital data contents being obtained by manipulating  
said first digital data contents with a  
30 predetermined manipulation method;  
transforming said first block data and  
said second block data into first frequency  
coefficients and second frequency coefficients  
respectively by applying an orthogonal transform;  
35 and  
obtaining a distribution of difference  
values between said first frequency coefficients and

said second frequency coefficients, said distribution function being an approximation of said distribution,

5 wherein said weights are assigned to said digital watermark sequence according to values of said distribution function.

10

63. The method as claimed in claim 61, wherein said weighting function is a distribution function obtained by a method comprising the steps of:

15 dividing first digital data contents into one or a plurality of first block data;

dividing second digital data contents into one or a plurality of second block data, said second digital data contents being obtained by manipulating 20 said first digital data contents with a predetermined manipulation method;

transforming said first block data and said second block data into first frequency coefficients and second frequency coefficients 25 respectively by applying an orthogonal transform; and

obtaining said distribution function on the basis of a theory if a distribution of difference values between said first frequency 30 coefficients and said second frequency coefficients can be obtained by said theory,

wherein said weights are assigned to said digital watermark sequence according to values of said distribution function.

35

64. An apparatus for reading digital watermark data from digital data contents in which each bit of digital watermark data is embedded a plurality of times, said apparatus comprising:  
means for receiving digital data contents;  
means for reading a digital watermark sequence from said digital data contents;  
means for performing soft decision in code theory by assigning weights to said digital watermark sequence with a weighting function; and  
means for reconstituting and generating digital watermark data from said digital watermark sequence.

15

65. The apparatus as claimed in claim 64, wherein said weighting function is a distribution function obtained by means comprising:  
means for dividing first digital data contents into one or a plurality of first block data;  
means for dividing second digital data contents into one or a plurality of second block data, said second digital data contents being obtained by manipulating said first digital data contents with a predetermined manipulation method;  
means for transforming said first block data and said second block data into first frequency coefficients and second frequency coefficients respectively by applying an orthogonal transform; and  
means for obtaining a distribution of difference values between said first frequency coefficients and said second frequency coefficients.

said distribution function being an approximation of  
said distribution,

wherein said weights are assigned to said  
digital watermark sequence according to values of  
5 said distribution function.

10               66. The apparatus as claimed in claim 64,  
wherein said weighting function is a distribution  
function obtained by means comprising:

means for dividing first digital data  
contents into one or a plurality of first block  
15 data;

means for dividing second digital data  
contents into one or a plurality of second block  
data, said second digital data contents being  
obtained by manipulating said first digital data  
20 contents with a predetermined manipulation method;

means for transforming said first block  
data and said second block data into first frequency  
coefficients and second frequency coefficients  
respectively by applying an orthogonal transform ;

25               means for obtaining said distribution  
function on the basis of a theory if a distribution  
of difference values between said first frequency  
coefficients and said second frequency coefficients  
can be obtained by said theory, and

30               wherein said weights are assigned to said  
digital watermark sequence according to values of  
said distribution function.

digital watermark data from digital data contents in which each bit of digital watermark data is embedded a plurality of times, said integrated circuit comprising:

- 5           means for receiving digital data contents;
- means for reading a digital watermark sequence from said digital data contents;
- means for performing soft decision in code theory by assigning weights to said digital
- 10          watermark sequence with a weighting function; and
- means for reconstituting and generating digital watermark data from said digital watermark sequence.

15

68. The integrated circuit as claimed in claim 67, wherein said weighting function is a distribution function obtained by means comprising :
  - 20          means for dividing first digital data contents into one or a plurality of first block data;
  - means for dividing second digital data contents into one or a plurality of second block data, said second digital data contents being obtained by manipulating said first digital data contents with a predetermined manipulation method;
  - means for transforming said first block data and said second block data into first frequency coefficients and second frequency coefficients respectively by applying an orthogonal transform; and
  - means for obtaining a distribution of difference values between said first frequency coefficients and said second frequency coefficients, said distribution function being an approximation of

said distribution,

wherein said weights are assigned to said digital watermark sequence according to values of said distribution function.

5

69. The integrated circuit as claimed in  
10 claim 67, wherein said weighting function is a distribution function obtained by means comprising:

means for dividing first digital data contents into one or a plurality of first block data;

15 means for dividing second digital data contents into one or a plurality of second block data, said second digital data contents being obtained by manipulating said first digital data contents with a predetermined manipulation method;

20 means for transforming said first block data and said second block data into first frequency coefficients and second frequency coefficients respectively by applying an orthogonal transform; and

25 means for obtaining said distribution function on the basis of a theory if a distribution of difference values between said first frequency coefficients and said second frequency coefficients can be obtained by said theory,

30 wherein said weights are assigned to said digital watermark sequence according to values of said distribution function.

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70. A computer readable medium storing

program code for causing a computer system to read digital watermark data from digital data contents in which each bit of digital watermark data is embedded a plurality of times, said computer readable medium comprising:

program code means for receiving digital data contents;

program code means for reading a digital watermark sequence from said digital data contents;

10 program code means for performing soft decision in code theory by assigning weights to said digital watermark sequence with a weighting function; and

program code means for reconstituting and 15 generating digital watermark data from said digital watermark sequence.

20

71. The computer readable medium as claimed in claim 70, wherein said weighting function is a distribution function obtained by program code means comprising:

25 program code means for dividing first digital data contents into one or a plurality of first block data;

program code means for dividing second digital data contents into one or a plurality of 30 second block data, said second digital data contents being obtained by manipulating said first digital data contents with a predetermined manipulation method;

35 program code means for transforming said first block data and said second block data into first frequency coefficients and second frequency coefficients respectively by applying an orthogonal

transform; and

5 program code means for obtaining a distribution of difference values between said first frequency coefficients and said second frequency coefficients, said distribution function being an approximation of said distribution,

wherein said weights are assigned to said digital watermark sequence according to values of said distribution function.

10

72. The computer readable medium as  
15 claimed in claim 70, wherein said weighting function is a distribution function obtained by program code means comprising:

20 program code means for dividing first digital data contents into one or a plurality of first block data;

25 program code means for dividing second digital data contents into one or a plurality of second block data, said second digital data contents being obtained by manipulating said first digital data contents with a predetermined manipulation method;

30 program code means for transforming said first block data and said second block data into first frequency coefficients and second frequency coefficients respectively by applying an orthogonal transform; and

35 program code means for obtaining said distribution function on the basis of a theory if a distribution of difference values between said first frequency coefficients and said second frequency coefficients can be obtained by said theory,

wherein said weights are assigned to said

digital watermark sequence according to values of  
said distribution function.

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